U.S. Patent Application of

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relating to a

TRANSFER OF OPTIMIZATION ALGORITHM PARAMETERS
DURING HANDOVER OF A MOBILE STATION
BETWEEN RADIO NETWORK SUBSYSTEMS

Express Mail No. EL 628637054 US

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TECHNICAL FIELD

2nd and 3rd generation cellular packet systems.

BACKGROUND OF THE INVENTION

10   In the Global System for Mobile Telecommunications/
General Packet Radio Service (GSM/GPRS) network
architecture, as shown in Fig. 13, there are known data
protocol stacks associated the various architectural
elements, including the mobile station (MS), base station
15   subsystem (BSS) including Base Transceiver Station (BTS)
and Base Station Controller (BSC), serving GPRS support
node (SGSN) and gateway GPRS support node (GGSN). The MS
and the SGSN share peer logical link control (LLC) and
subnetwork-dependent convergence protocol (SNDCP) layers
20   in the user plane.

A typical GPRS negotiation that is required between
peer entities in the mobile station and some of the fixed
network devices is the exchange identification or XID
negotiation, where so-called L3CE (layer 3 compatibility
25   entity) parameters are agreed upon.

The UMTS packet network architecture is highly
similar to GPRS. However, the naming of some elements and
interfaces has been changed from GPRS. While Fig. 13
shows the GPRS network architecture, Fig. 14 shows the
30   UMTS packet network architecture.

The UMTS packet network consists of the following
network elements:
Node B: corresponds to Base Transceiver Station (BTS) in
GSM.
35   **RNC** (Radio Network Controller): corresponds to Base
Station Controller (BSC) in GSM.

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3G-SGSN: the 3rd Generation version of the Serving GPRS
Support Node (SGSN) of GSM/GPRS.

3G-GGSN: the 3rd Generation version of the Gateway GPRS
Support Node (GGSN).

5   **HLR**: the GSM Home Location Register (HLR) with some
updates.

As shown in Fig. 14, Node B and RNC comprise the RAN
part of the UMTS network.   RAN corresponds to GSM's BSS.
The responsibility of RAN is the handling of all radio
10   specific functions, e.g., radio channel ciphering, power
control, radio bearer connection setup and release.   The
basic separation between elements is that Node B handles
the physical layer functions and RNC handles the
management functions.   However, the separation might
15   ultimately turn out to be slightly different than in
GSM/GPRS.

The biggest architectural difference is the new
interface, Iur, inside RAN.   It is resident between RNCs.
UMTS introduces a new concept called macrodiversity.   In
20   a macrodiversity situation, data is sent via multiple
Node Bs.   Because signals are transferred via multiple
routes over the air interface and combined in the MS and
the RNC, e.g., the fading effect is less harmful and thus
lower power levels can be used.   However, those Node Bs
25   may belong to the area of two or more different RNCs, so
the interface, i.e., Iur-interface between RNCs is
required. In this situation, as shown on the right in
Fig. 15, RNC can be in two logical roles. RNC can be
logically either:

30   drift RNC (DRNC) or
serving RNC (SRNC).

The actual termination point of the Iu-interface is
at the SRNC.   The Iu-interface shown in Fig. 14 connects
the Radio Access Network (RAN) and Core Network (CN) for

packet-switched or circuit switched services. The SRNC controls information transfer and requests radio resources from appropriate DRNCs. The DRNC only relays information between MS and SRNC.

5   The Core Network (CN) part of the packet-switched side consists of 3G-SGSN, 3G-GGSN and HLR elements, as shown in Fig. 14. The Packet Core Network (CN) also includes the IP-based backbone network. The backbone connects core network elements, e.g., 3G-SGSN and 3G-GGSN

10   together.

3G-SGSN participates in routing of user packets as well as mobility and session management functions. The Mobility Management (MM) layer knows "who you are (security) and where you are (mobility)". The Session

15   Management (SM) layer controls the user connections, i.e., sessions.

3G-GGSN maintains the location information of 3G-SGSN, which serves the mobile station to which a packet is targeted. The main function of 3G-GGSN is to perform

20   interworking functions between the UMTS network and the external data network, e.g., the Internet. These interworking functions include, e.g., the mapping of the external QoS to a comparable UMTS QoS.

HLR stores the subscriber data and holds the

25   information to which 3G-SGSN the user is connected. The subscriber data includes predefined QoS attributes for the user connections, among other things.

The UMTS packet data protocol stack has some major modifications compared to GPRS, partly due to the new

30   radio interface technology (WCDMA) and partly due to much higher QoS requirements.

One of the most important changes is that Logical Link Control layer (LLC) of ESM/GPRS has been removed below the Layer 3 Compatibility Entity (L3CE). L3CE

corresponds to SubNetwork Dependent Convergence Protocol
(SNDCP) protocol in GPRS. The main tasks of the LLC
protocol have been:

      flow control between MS and core network,

5   ciphering,

      signaling message transfer,

      multiplexing of different QoS and

      retransmission between MS and the core network.

      In UMTS, LLC is not needed due to the following

10 reasons: 1) Ciphering has been decided to take place in
lower layers, inside RAN. 2) Signaling message transfer
does not use user plane protocols, because there are
separate protocols for transferring signaling messages
and thus the differentation between the user plane and

15 the control plane is clearer than in GPRS.

      In the UMTS radio interface, each radio bearer will
have its own Radio Link Control (RLC) entity. By
applying this approach the QoS provisioning is more
efficient. The QoS related multiplexing will be a task

20 for the Medium Access Control (MAC) layer and Layer 1
(L1) and thus LLC would not have any role in QoS
multiplexing in UMTS. The retransmission between the MS
and the core network cannot be easily justified. The main
source of the errors is the radio interface, and RLC has

25 the responsibility to correct those errors.

      However, the removal of LLC will cause a lack of
flow control between the MS and the core network. The
flow control in the uplink is not a problem, because the
radio interface will be the bottleneck and flow control

30 of RLC takes care of it. In the downlink, RLC will
handle the RNC - MS part. Between RNC and the core
network, there is no flow control. But this is not a
much worse situation than in GPRS, because GPRS does not
have any flow control inside the core network (between

GGSN and SGSN).

Adequate data transfer between 3G-GGSN and RNC relies on large enough buffers, traffic policing in 3G-GGSN and end-to-end flow control, e.g., Transmission

5   Control Protocol (TCP). In general, the removing of LLC streamlines the protocol stack and makes it easier to achieve higher data rates and reduces required processing power.

The location of the UMTS counterpart to L3CE (SNDCP

10   in GPRS) called Packet Data Convergence Protocol (PDCP) is under consideration. Unlike in GPRS the PDCP layer is located in RNC instead of SGSN. The protocol *inter alia* takes care of optimization, e.g., by header compression, which is a form of optimization algorithm. Some header

15   compression algorithms are based on the principle that disappearence of a few packets may cause undesirable additional packet loss due to the algorithm itself. This degrades packet transfer because more retransmissions are needed to be done. By locating it to the RNC, the

20   retransmission time is short and the TCP level retransmission (due to TCP timers) can be avoided.

Network layer protocols are intended to be capable of operating over services derived from a wide variety of subnetworks and data links. The PDCP supports several

25   network layer protocols providing protocol transparency for the users of the service. An introduction of new network layer protocols to be transferred over PDCP should be possible without any changes to other UMTS protocols. Therefore, all functions related to

30   transferring of Network Layer Protocol Data Units (N-PDUs) are carried out in a transparent way by the network entities. Another requirement for PDCP is to provide functions that improve data and channel efficiency. This is done by different kind of optimization algorithms or

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methods, e.g., the above-mentioned header compression.

UMTS (Universal Mobile Telecommunications System), as shown in Fig. 14, utilizes similar protocol structures and negotiation arrangements for communication between
5 mobile stations, Radio Network Controllers (RNCs) and service nodes of packet-switched networks, with some modification. Exchange Identification (XID) negotiation is carried out by the PDCP but is called PDCP parameter negotiation and can be viewed generally as a transfer of
10 optimization algorithm parameters.

In either case, the negotiated parameters will relate to such optimization algorithm parameters, for example, to the use of headers and data compression. The GSM/GPRS method for arranging an XID negotiation is to
15 insert the proposed parameters into certain messages in an LLC protocol layer and to use corresponding LLC-level answering messages to either acknowledge or reject the proposed SNDCP parameters.

The XID negotiation is usually made when SNDCP and
20 LLC in GPRS are initialized (values for XID parameters are no longer valid). This initialization is made, e.g., when the MS is powered on or the location of network side protocols changes in handover.

The main problem of the currently-proposed XID
25 negotiation method for UMTS is that the location of PDCP is different from the location of SNDCP and LLC protocol. PDCP locates in the radio access network while comparable GPRS protocols locate in core networks. This means that the location of PDCP changes far more often than the
30 locations of SNDCP and LLC. Because XID messages may be relatively large, this adds much more overhead to the air interface in UMTS than in GPRS.

Another problem is that UMTS has also real time packet connections. This means that negotiations such as

XID should be as fast as possible, because otherwise it may cause delays or at least more overhead in the air interface (header compression cannot be used after handover until XID negotiation is successfully made).

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SUMMARY OF INVENTION

The object of the invention is to provide for improved UMTS as well as GSM/GPRS negotiation methods.

This invention improves any negotiation, such as
10 optimization algorithm parameter negotiation, e.g., XID negotiation, by reducing the overhead over the air interface and making the negotiation procedure faster. The basic idea of the invention is that during handover, parameters such as XID, containing parameter information
15 about optimization methods to be supported, are transferred from the old entity to the new entity on the network side. If the parameters were appropriate in the new entity, the actual negotiation between the MS and the network is not needed, thus saving resources on the air
20 interface. This method is also considerably faster than, for instance, normal XID negotiation.

According to the present invention, a method of negotiating such as negotiating optimization algorithm parameters, for instance exchange identification (XID)
25 parameters during connection handover of a mobile station between radio network subsystems, comprises the steps of signaling from a source radio network subsystem to a core network or to a target radio network subsystem that said handover is required, signaling from the core network or
30 from the target radio network subsystem to the source radio network subsystem that said handover is to proceed, and transmitting said parameters from said source radio network subsystem to said target radio network subsystem directly or via the core network without any need for

renegotiating over an air interface between said mobile station and said target radio network subsystem.

In further accord with the present invention, wherein during initial establishment of said connection between the mobile station and the source radio network subsystem, the optimization algorithm paramaters such as exchange identification parameters may include various optional sets of parameters, only one of which is accepted by the source radio network subsystem, said method further comprising the step of storing all of said optional sets of parameters wherein said step of transmitting said parameter includes transmitting all of said optional sets of parameters.

From the foregoing, it will be realized that the present invention indeed saves resources for the air interface and makes any kind of negotiation, including negotiation of parameters relating to optimization methods such as XID faster, which is advantageous for real time connections.

These and other objects, features and advantages of the present invention will become more apparent in light of the detailed description of a best mode embodiment thereof, as illustrated in the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

Fig. 1 shows a source radio network controller (RNC) moving already-negotiated XID parameters to a target RNC during handover, according to the present invention.

Fig. 2 shows a simplified procedure of SRNS relocation according to the present invention.

Fig. 3 shows an MSC connecting to the network.

Fig. 4 shows MSC initialization.

Fig. 5 shows MSC SRNS relocation.

Fig. 6 also shows MSC SRNS relocation.

Fig. 7 shows a situation before SRNS relocation and location registration.

Fig. 8 shows the situation after the SRNS relocation and location registration.

5   Fig. 9 shows how Figs. 9A and 9B fit together.

Figs. 9A and 9B together show the signaling sequence concerning interface information transfer for SRNS relocation update when changing SGSN area resulting in a change of register location and followed by location

10   registration in a new location area.

Fig. 10 shows data paths before the SRNS relocation has been actually committed.

Fig. 11 shows data paths after the GGSN update.

Fig. 12 shows data paths after the resource release

15   in the source RNC.

Fig. 13 shows the GPRS network architecture.

Fig. 14 shows the UMTS packet network architecture.

Fig. 15 shows two logical RNCs.

20   BEST MODE FOR CARRYING OUT THE INVENTION

The first XID negotiation after the MS is connected to the network is always a normal GPRS type of XID negotiation, as in the prior art. The GPRS XID parameter negotiation as part of the SNDCP protocol is defined in

25   TS 101 297 v.6.4.0 (1999-08) (GSM 04.65 version 6.4.0 Release 1997 (chapter 6.8)).

Similarly, during inter RNC handover (SRNS relocation), according to the currently-proposed evolution of the GSM platform towards UMTS, the control

30   point of data transfer moves from a source RNC (RNC 1) to a target RNC (RNC 2) and thus a new PDCP entity is established to the target RNC network element. However this new PDCP entity should negotiate XID parameters, before it starts data transfer towards the MS (PDCP can

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transfer data before it knows negotiated XID parameters,
but then it is allowed only use default values of XID
parameters -> no optimization is allowed, e.g., header
compression).

5   The prior art basic solution (as in GPRS) is still
that the target RNC makes normal XID negotiation between
itself and the MS and after that starts data transfer.

A more advantageous solution according to the
present invention, and as illustrated in Fig. 1, is that
10   the source RNC 16 (RNC 1) moves the already-negotiated
XID parameters to the target RNC 20 (RNC 2) during
handover, i.e., SRNS relocation directly or via SGSN 26
(see 3G TS 23.121 v3.0.0 - chapter 4.3.12.2.3).

Fig. 1 shows a pair of radio network subsystems 11,
15   12 connected to the core network 14 through an Iu
interface. The radio network system 11 consists of a
radio network controller 16 and one or more abstract
entities 18, which may be called Node B, which
corresponds to the Base Transceiver Subsystem of GSM.
20   The entities of Node B are connected to the RNC through
an Iub interface. A Node B can support FDD mode, TDD
mode or dual-mode operation. The RNC is responsible for
handover decisions that require signaling to the mobile
station 10 over a Uu interface. The RNC comprises a
25   combining/splitting function to support macrodiversity
between different Node Bs. The Node B can comprise an
optional combining/splitting function to support
macrodiversity inside a Node B. The RNCs 16, 20 of the
radio network subsystems 11, 12 can be interconnected
30   together through an Iur interface, as already discussed
previously in connection with Fig. 14.

Each RNC is responsible for the resources of its set
of cells. For each connection between a user equipment,
such as the mobile station MS 10 of Fig. 1, and the

illustrated access/core architecture, one RNC is the
serving RNC. In Fig. 1, the RNC1 16 is initially the
serving RNC. The RNC2 20 serves as a drift RNC (see also
Fig. 15) and supports the serving RNC1 16 by providing

5   radio resources for possible handover. Upon such a
handover, as suggested above, during the inter-RNC
handover, the control point of data transfer moves from
RNC1 16 to RNC2 20 for establishing a new PDCP entity to
the target RNC2 20. According to the prior art, this new

10   PDCP entity should first negotiate PDCP parameters,
before it starts data transfer to the MS, unless it
wishes to only use the default values, i.e., without
optimization.

   According to the present invention, rather than

15   renegotiating, such as renegotiating optimization
algorithm parameters, for instance PDCP parameters all
over again, the RNC1 16 transfers the already-negotiated
PDCP parameters to RNC2 20, as indicated on a line 24,
which transfer may take place over the Iur interface or

20   through the core network 14, e.g., via a serving GPRS
support node (SGSN) 26.

   Fig. 2 shows an embodiment that represents a
simplified procedure of SRNC relocation where two SGSNs
are involved in the core network. One possible solution

25   for PDCP parameter transfer is the use of SRNC relocation
messages (e.g., SRNC_Relocation_Required 30,
Forward_SRNC_Relocation 32 (e.g., if RNS1 and RNS2 are
connected to different SGSNs, to possibly another SGSN 27
not shown in Fig. 1), SRNC_Relocation_Request 34 to the

30   target SRNC 20, SRNC's Relocation_Proceeding 1 36,
Forward_SRNC_Relocation Response 38,
SRNC_Relocation_Proceed 2 40, SRNC_Relocation_Commit 42,
RNC_Restart_44, Data_Transmission_Begin 46,
PDCP_Parameter_Request (if needed) 48,

PDCP_Parameter_Response (if needed) 50). The format of
PDCP parameters can be the same as in normal prior art
XID negotiation. After the target RNC2 20 receives these
PDCP parameters, it checks their validity. If they are

5   valid, it can use the parameters immediately. Otherwise
the target RNC makes a normal XID-type negotiation, as
suggested in Fig. 2 at steps 48, 50. So PDCP negotiation
between the MS and the target RNC is made only when PDCP
parameters are not valid in the target RNC and therefore

10   air resources are saved.
         However, the MS requires information about the
validity of the PDCP parameters before it can send data
to the RNC (MS can't otherwise know whether PDCP
parameters were alright in the RNC). There are two

15   options:
         Preferable solution: RNC informs the MS about
validity of XID parameter during/before RLC restart
within separate message, e.g., during step 44 of Fig. 2.
     If PDCP parameters were valid, both ends can use same

20   negotiated PDCP parameters immediately. If PDCP
parameters were not valid, PDCP negotiation is made after
restart, as shown, e.g., in steps 48, 50. Until PDCP
negotiation is completed, all data packets are sent in
uncompressed mode, i.e., the default mode.

25   Another solution: It can be guaranteed, that PDCP
parameter negotiation can be made before data transfer
(preferably before RLC restart step 44), if it is needed.
     (This might cause delays to SRNC relocation, however.)
         This retrieval of PDCP parameters from the source

30   RNC, as described so far, has one disadvantage. The
target RNC can't know if the MS can handle 'better' PDCP
parameters, e.g., better compression methods than
originally negotiated between the MS and the source RNC
16 (RNC 1).

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Example:

-       MS can handle header compression methods A and B
-       RNC 1 can handle header compression method A
-       RNC 2 can handle header compression methods A and B.

5   Because PDCP negotiation is made originally by RNC
1, only header compression A is negotiated for use.
After SRNC relocation, RNC 2 checks the validity of the
PDCP parameters. In the example they are valid, because
RNC 2 can handle header compression A. The problem is

10   that, in this situation, PDCP negotiation between MS is
not made and header compression B is not taken up for
use. If the header compression B is significantly
better, it causes inefficiency. (Normal PDCP negotiation
takes always the best XID parameters for use.)

15   This problem can be avoided, according further to
the invention, with the following enhancements:

Firstly, the initial XID negotiation (first XID
negotiation after MS is connected to the network) is
always started from the MS side. (This is a normal

20   situation in GPRS). The MS defines and puts suitable
PDCP parameters into the PDCP message. Then the peer
entity, i.e., RNC, negotiates, i.e., selects appropriate
PDCP parameters and sets suitable values to them. After
that the RNC returns negotiated XID parameters to the MS

25   and the negotiated parameters are taken up for use.

However, if the RNC stores in addition to negotiated
PDCP parameters also the 'not used' or discarded PDCP
parameters (in the example, it stores information on
header compression B), when SRNC relocation is made, the

30   'not used' PDCP parameters are retrieved from storage and
are also transferred to the target RNC. (The same SRNC
relocation messages are used then on transfer or
negotiated PDCP parameters.) According to this
information, the target RNC can decide if those 'not

used' XID parameters are 'better' (in the example, header compression B) than currently negotiated and make PDCP negotiation between MS to take up for use new and 'better' XID parameters.

5   A few examples of Negotiation of Header Compression (HC) parameters according to the invention will now be given.

Example 1:

10   An example of negotiation of header compression (HC) parameters is shown in Fig. 3. When Mobile Station connects to the network RRCs with a *UE CAPABILITY INFORMATION* message is used to inform the SRNC of the header compression (HC) methods that UE is able to use

15   and the parameters thereof. This information is left to the network to be updated and taken care of.

      After comparing the network's own and these received parameters, the network makes a decision of the HC-method to be used, also taking into consideration the QoS

20   requirements. Thus it is possible to choose the most probable HC method (in other words, according to QoS requirements the first configured method can be chosen to be real-time traffic optimized method or not). After the network has made the decision it configures its own

25   compressor, generates the OPT value table and commands using RRC messages *RADIO BEARER SETUP* (Fig. 4) or *RADIO BEARER RECONFIGURATION* (Fig. 5) the parameters relating to that algorithm with which the compressor in the UE end is configured. At the same time the OPT table is

30   generated to match the table of the network's end. The VE_RRC responds with a RADIO_BEARER_SETUP_COMPLETE (Fig. 4) message to the SRNC_RRC or with a RADIO_BEARER_RECONFIGURATION_COMPLETE (Fig. 5) message in case of reconfiguration.

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Because the network knows (Fig. 3) which algorithms the UE and the network itself are able to use, it is possible to configure a new compressor in case other kinds of packets (different from what is supported by

5   current compressor) are recognized and the compression of these is supported by the network and the UE. In that case, new compressors will be configured at both ends immediately. If the notification is in the UE end, these are sent firstly to the RNC uncompressed and after the

10   RNC notices the situation it configures the compressors at both ends. The new compressor at the UE end is configured using a *RADIO BEARER RECONFIGURATION* (Fig. 5) message containing the information, which is sent when the new method is being configured.

15   Because the network maintains the information of all possible methods for use at both the UE and the network and because only the most probable method is being configured, it is possible to leave the compressors of other methods to be configured later if needed.

20   In case of SRNS relocation, as detailed in Fig. 6, after the last *SRNC_relocation_Commit* message, a *new RNC RADIO BEARER RECONFIGURATION* (Fig. 5) message is sent, wherein new HC parameters are communicated if the method changes. In case the method doesn't change, only old

25   parameters are communicated and information about the reset (yes/no) of the compressor is transmitted. If there is no resetting then the compression/decompression continues as it was in the old RNC.

30   Example 2:

Again, when the Mobile Station connects to the network RRCs with the *UE CAPABILITY INFORMATION* message of Fig. 3, the SRNC_RNC is informed of the desired header compression (HC) methods that the UE is able to use and

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the related parameters. This information is left to the network to be updated and taken care of.

The network chooses the methods that can be supported based on its own supported methods as well as
5   those of the UE. After this the network could send the parameters of all the supported methods at the same time with a message to the UE. This would mean that both the network and the UE would know which methods can be supported. In this case also the OPT table indicating
10 different packet types of different methods is generated to be similar at both ends. This information transfer can be carried out by using RRC's *RADIO BEARER SETUP*, as shown in Fig. 4, or *RADIO BEARER RECONFIGURATION* messages, as shown in Fig. 5. At the same time the most
15 probable method is informed and configured and the compressor is created.

In case the configured compressor is, e.g., TCP/IP but afterwards RTP/UDP/IP real-time packets are recognized, PDCP recognizes the situation and generates a
20 new compressor for those. This new RTP/UDP/IP compressor is configured and inside the compressor the stream-based contexts are generated and stream-based Full Headers (FH) are sent to the other end. The link layer informs using the OPT-field about what compression method is in
25 question and that it deals with that method's Full Header (FH). The other end notices the situation, configures the decompressor and generates (using FHs) the correct internal contexts for existing streams. In this situation no *RADIO BEARER RECONFIGURATION* messages need
30 to be sent. After this the compressor is able to send compressed packets without further acts. This solution works independently of the transmission end (UE/network).

Another solution is that for all supported methods each end's own compressors are configured immediately in

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the beginning, meaning that compressor configuration is done only once. In this case inside the compressor only the own specific stream-based contexts are generated and stream-based Full Headers (FH) are sent to the other end.

5 Also if the same compressor supports two methods the configuration is not needed but only one's own stream-based compressor contexts are generated and FHs sent to the other end.

Again, in SRNS relocation after

10 *SRNC_relocation_Commit* message, as shown in Fig. 6, a new *RNC RADIO BEARER RECONFIGURATION* message is being sent (Fig. 5), wherein the UE is informed if the method changes. In case the method doesn't change only information about the reset (yes/no) of the compressor is

15 sent. If there is no resetting then the compression/decompression continues as it was in the old RNC.

Example 3:

20 It is also possible that network informs the UE about the methods it supports when connecting to the network and in case of SRNS relocation after *SRNC_relocation_Commit* message. In this case UE begins the transmission of compressor parameters using some

25 *RADIO BEARER SETUP* (Fig. 4) and *RADIO BEARER RECONFIGURATION* (Fig. 5) based signaling and the compressor generating procedure according to example 1 or 2 with the difference that UE sends the configuration messages and network receives them.

30 The current (prior art) solution in GPRS is that XID negotiation is made again when the location of SGSN changes (inter SGSN handover). This negotiation is required, because the SNDCP and LLC protocols locate in SGSN and the old XID parameters are not known in the new

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SGSN (and they may also be non-applicable). XID
negotiation is made for certain (most, but not all) LLC
and SNDCP parameters, e.g., header compression
parameters.

5   However, this approach is not very suitable for
UMTS.
-      In UMTS, the PDCP is located in RNC, so negotiation
will have to be made more often.
-      UMTS has real time bearers also for packet data.
10 -   Negotiation would be fast as possible.
       Note: PDCP parameter negotiation is probably not to
be named XID-negotiation, just PDCP parameter negotiation
in UMTS.

15 Possible alternatives to make PDCP negotiation between UE
and target RNC:
       In the following, SRNS relocation is described in
detail. All necessary information is transferred from
the source RNC to the target RNC.
20 - negotiated PDCP parameters -> target RNC, whether they
are OK or not for it. If they are, new negotiation is
not needed and air resources and time are saved.
- UE capability information -> this includes UE's PDCP
capability information among other capabilities. PDCP
25 capability information may contain, e.g., the following
information: PDCP version number and supported header
compression methods and other parameters. This is not
mandatory.

30   1) One solution is that network commands (RRC
protocol in RNC), what parameters are used in the UE (in
different radio layer protocols, L1, MAC; RLC, PDCP).
This is not an actual two-way negotiation like XID
negotiation. However the network shall know what

parameters the UE is able to support (because the network can't command what the UE can't support). This UE capability can be transferred from source SRNC (suggested) or requested from the UE by 'UE capability

5   enquiry' (see RRC specification - TS 25.331 v1.5.0: Chapters 8.1.6 and 8.1.7). Now the target SRNC can negotiate (command) new parameters for the UE. The current (prior art) solution is that the parameters are transferred within 'Radio Bearer Setup/Reconfiguration'

10   messages (see TS 25.332: Chapter 8.2). Actual PDCP parameters should probably be named as 'PDCP Info' like 'RLC info' (see table in chapter 10.1.5.4). Also other messages (new or existing ones) are possible.

In a case where the parameters were OK in the target

15   SRNC:
- An indication is provided that previously negotiated parameters were OK. Both sides use old parameters. This indication can be one's own RRC level message or part of a 'Radio Bearer Setup/Reconfiguration'-message. This

20   indication can be very short (1 bit), to indicate whether the negotiated parameters were OK or not.

In a case when parameters were not OK in the target SRNC:
- The target RNC commands new parameters taking into

25   consideration the UE's capability. (Normal PDCP parameter negotiation).

In this solution, there is no time saving, because negotiation is one way.

2) In this solution, PDCP parameter negotiation is

30   two-way between the network (RNC) and the UE. In this case, UE capability information is not mandatory (but such may help the target SRNC, when it negotiates new parameters). After SRNC receives the to be negotiated parameters, it checks the suitability of the parameters.

In a case where parameters are OK in target SRNC:
- An indication is provided that the previously
negotiated parameters are OK. Both sides use the old

5   parameters. This indication can be one's own RRC level
message or part of a 'Radio Bearer
Setup/Reconfiguration'-message. This indication can be
very short (1 bit), to indicate whether negotiated
parameters were OK or not.

10   In a case where parameters were not OK in target
SRNC:
- The target RNC negotiates new parameters. (Two-way
PDCP parameter negotiation). First direction message
(request) may be same as in solution 1), i.e., 'Radio

15   Bearer Setup/Reconfiguration', such as in Figs. 4 or 5,
and second direction message (reply) could be 'Radio
Bearer Setup/Reconfiguration Complete' (see chapter
10.1.5.5). Also new (own) messages for PDCP negotiation
in RRC protocol may be possible.

20   In this solution, time is saved, because two-way
negotiation needs to be made only when parameters weren't
OK.

Note: In both solutions it is assumed that the RRC
makes the PDCP negotiation and after negotiation (if

25   needed) RRC informs new parameters to PDCP. An
alternative solution is that PDCP makes the negotiation
by itself. Then RRC messages are not used, but PDCP uses
its own PDUs for negotiation. However the basic
principles are the same also in this case.

30   A similar approach could be used also in future
releases of GPRS.

SRNS relocation principles according to 3G TS 23.121 v
3.1.0 (1999-10) 3G PP Technical Specification Group

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Services and Systems Aspects; Architectural Requirements for Release 1999 at Section 4.3.14.2, as modified according to the present invention:

5   According to Chapter 4.3.14.2.1 of 3G TS 23.121, to carry out SRNS relocation, the source SRNC must launch the SRNS relocation procedure, since it is not the target SRNC but the source SRNC that knows the current services of a user. This is done only when this procedure has the

10   least adverse effect on user traffic. The SRNC relocation procedures must ensure that there is only one Serving RNC for a user even if this user has services through more than one (IP or ISDN) domain.
       The SRNS relocation procedure is split in two

15   phases. In the first phase resources are reserved on the new IU interfaces and (if needed) inside the CN. Only when this first phase has been successfully carried out for all domains on which the user currently has some services, can the source SRNC launch the second phase,

20   i.e., handover of the role of SRNC to the target SRNC.
       The signaling procedures shown below do not represent the complete set of possibilities, according to the TS 23.121 specification, nor do they mandate this kind of operation. It should be understood according to

25   the standard, that a set of elementary procedures should be specified for each interface, which may be combined in different ways in an implementation. Therefore the illustrative sequences are merely examples of a typical implementation. In these examples from the 3G TS 23.121

30   standard, MSC stands for 3G_MSC/VLR and SGSN stands for 3G_SGSN.

SRNS relocation
(UE connected to a single CN node, 3G_SGSN)
followed by Location Registration in new Location Area as
per Chapter 4.3.14.2.3 of 3G TS 23.121 as modified by the
5   present invention

This example shows SRNS relocation when source RNC
and target RNC are connected to different 3G_SGSNs. Fig.
7 and Fig. 8 respectively illustrate the situation before
10   and after the SRNS relocation and location registration.
Fig. 9 illustrates the signaling sequence where each step
is explained below.

As shown in Fig. 7, before the SRNS relocation and
location registration the UE is registered in SGSN1 and
15   in MSC1. The UE is in state MM connected towards the
SGSN1 and in state MM idle (see Chapter 4.3 UMTS Mobility
Management (UMM) in 3G TS 23.121) towards the MSC1. The
RNC1 is acting as SRNC and the RNC2 is acting as DRNC.

After the SRNS relocation and location registration
20   as shown in Fig. 8, the UE is registered in MSC2 and in
SGSN2. The UE is in state MM connected towards the SGSN2
and in state MM idle towards the MSC2. The RNC2 is
acting as SRNC.
At SRNS relocation:
25   The source and target SGSN exchange CN level information
(CN classmark, list of established PDP contexts)
The source and target SRNC exchange UTRAN level
information (UTRAN classmark, ...) and information used
to ensure that no user packet is lost nor duplicated
30   during the SRNS relocation procedure. According to the
teachings of the present invention, this UTRAN level
information also includes negotiated PDCP (XID)
parameters.

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"Resource reservation" Phase

During this phase, according further to Chapter 4.3.14.2.3 of 3G TS 23.121 v 3.1.0 (1999-10), the

5 transmission of packets between GGSN and UE through the source SRNC goes on. The following numbered paragraphs correspond to the numbered steps in Figs. 9A and 9B, which fit together as shown in Fig. 9.

1. UTRAN (source SRNC) makes the decision to perform

10 the Serving RNC relocation procedure. This includes a decision on into which RNC (Target RNC) the Serving RNC functionality is to be relocated. The source SRNC sends SRNC Relocation Required messages to the SGSN1. This message includes parameters such as target RNC identifier

15 and an information field that shall be passed transparently to the target RNC. According to the present invention, this may include negotiated PDCP (XID) parameters, UE capability (e.g., supported header compression methods by UE) and any other related

20 parameters.

2. Upon reception of SRNC Relocation required message the SGSN1 determines from the received information that the SRNC relocation will (for instance, in this case) result in a change of SGSN.

25 The SGSN will then send a Forward SRNC relocation request to the applicable SGSN (e.g., SGSN2) including the information received from the Source SRNC (see above PDCP (XID) parameter information according to the invention) and necessary information for the change of

30 SGSN (e.g., MM context, PDP context). The PDP context information contains the list of the PDP context (including PDP type, requested/negotiated QoS) currently established by the UE along with the address of the

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associated GGSN. It does not contain any information
linked with packet transmission (sequence numbers)
because such information is under the responsibility of
the UTRAN.

5   3.   The SGSN2 sends a SRNC Relocation Request message to
the target RNC. This message includes information for
building up the SRNC context, transparently sent from
Source SRNC (e.g., UE id., number of connected CN nodes,
UE capability information (including the inventive

10   information transfer relating to PDCP (XID) parameters
described above), and directives for setting up Iu user
plane transport bearers.
     When the Iu user plane transport bearers have been
established, and the target RNC completed its preparation

15   phase, SRNC Relocation Proceeding 1 message is sent to
the SGSN2, as shown in Figs. 9A and 9B. *The SRNC
Relocation Proceeding 1 message* contains the IP
address(es) (possibly one address per PDP context) on
which the target RNC is willing to receive these packets.

20   4.   When the traffic resources between target RNC and
SGSN2 has been allocated and the SGSN2 is ready for the
SRNC move, then the Forward SRNC Relocation Response is
sent from SGSN2 to SGSN1. This message indicates that
necessary resources have been allocated for the SRNC

25   relocation: SGSN2/target RNC are ready to receive from
source SRNC the downstream packets not yet acknowledged
by UE. *The Forward SRNC Relocation Response message*
contains the IP address(es) that were given in the SRNC
Relocation Proceeding 1 message.

30   5.   When the Forward SRNC Relocation Response has been
received in the SGSN1, the SGSN1 indicates the completion
of preparation phase at the CN PS domain side for the

SRNC relocation by sending the SRNC Relocation Proceeding 2 message to the Source RNC. This message contains the IP address(es) (possibly one address per PDP context) on which to send the downstream packets not yet acknowledged
5   by UE.

"Actual hand-over of Serving RNC" Phase

6.   When the source RNC has received the SRNC Relocation Proceeding 2 message, the source RNC sends a SRNC
10   Relocation Commit message to the target RNC (list of (SNU, UP_RLC_Ack, SND)). SND is the GTP sequence number for the next downlink packet received from the GGSN. SNU is the GTP sequence number for the next uplink packet to be tunnelled to the GGSN. UP_RLC_Ack contains the
15   acknowledgements for an upstream PDU received by the source SRNC on each RLC connection used by the UE (i.e., the Receive State Variable V(R) for all RLC SAPI in the acknowledged mode). The source SRNC starts a timer T3-TUNNEL, stops the exchange of the packets with the UE
20   (point (a)), and starts tunnelling the buffered downstream packets towards the target SRNC. The target RNC executes a switch for all bearers at the earliest suitable time instance. In this phase, according to the present invention, new PDCP parameters are to be
25   negotiated if needed. See the description above concerning possible alternatives for PDCP negotiation between the UE and the RNC.

7.   The target RNC starts acting as SRNC and the remaining steps 7-14 of Chapter 4.3.14.2.3 of 3G TS
30   23.121 v 3.1.0 (1999-10) remain the same and are unaffected by the present invention. The target SRNC:

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(a)   Restarts the RLC connections. This includes the exchange between the target SRNC and the UE of the UP_RLC_Ack and DOWN_RLC_ACK. DOWN_RLC_ACK confirms all mobile-terminated packets successfully transferred before the start of the relocation procedure. If DOWN_RLC_ACK confirms reception of packets that were forwarded from the source SRNC, then these packets shall be discarded by the target SRNC. UP_RLC_Ack confirms all mobile-originated packets successfully transferred before the start of the relocation procedure. From now on the exchange of the packets with the UE can restart (point (b)).

(b)   Sends New MM System Information to the UE indicating, e.g., relevant Routing Area and Location Area. A new RAI triggers a routing area update procedure. Additional RRC information may then also be sent to the UE, e.g., new RNTI identity. This may trigger a location update procedure (see step 12 below).

8.   Immediately after a successful switch at RNC, target RNC (=SRNC) sends SRNC Relocation Detect message to the SGSN2. After sending out the New MM System Information, the target RNC sends SRNC Relocation Complete message to the SGSN2.

9.   The UE sends a Routing area update request (old RAI; old P-TMSI; old PTMSI signature, Update type) to SGSN2 when the New MM System Information included a new RAI.

10. Upon reception of RAU request, the SGSN2 updates the GGSN(s) with an Update PDP Context Request including the new SGSN address. The GGSN(s) then update the PDP context and return Update PDP Context Response. The SGSN

sends a Complete SRNC Relocation towards the SGSN1.

11.   At reception of the Complete SRNC Relocation, SGSN1 will send a release indication towards the Source RNC. All resources allocated to this UE by the source RNC are
5   released only when this message has been received and timer T3-TUNNEL has expired.   Before timer T3-TUNNEL expires, all downstream packets received from the GGSN are sent towards the target SRNC.

12.   The SGSN2 informs the HLR of the change of SGSN by
10   sending Update GPRS location (IMSI, new SGSN address etc.) to the HLR.   The HLR cancels the context in the old SGSN, SGSN1, by sending Cancel Location (IMSI).   The ,SGSN1 removes the context and acknowledges with Cancel Location Ack.   The HLR sends Insert subscriber data
15   (IMSI, subscription data) to the SGSN2.   The SGSN2 acknowledges with Insert Subscriber Data Ack.   The HLR acknowledges the Update GPRS location by sending Update GPRS Location Ack to the SGSN2.

13.   At reception of Insert subscriber data from HLR, the
20   SGSN2 will initiate the update of MM information stored in the UE.   This is done by sending Network Initiated Routing Area Update Command to the UE. This message will include new RAI, and possible also new P-TMSI.   When the UE has made necessary updates it answers with Network
25   Initiated Routing Area Update Complete.

14.   When receiving new MM system information indicating a new Location Area, the UE will, in this case, initiate a Location Area update procedure towards the MSC2.   This implies that the Location Area update will be performed
30   in parallel to the above indicated activities related to the SGSN side of the Core Network.

UE-GGSN Communication path during the SRNS
relocation procedure

5   Before point (a), in Fig. 9A, the connection is
established between UE and GGSN via Source SRNC and
SGSN1, as shown in Fig. 10 (Fig. 4-28 of 3G TS 23.121 v
3.1.0).

       After transmission of the "SRNS relocation commit"
10   to the target SRNC (after point (a) in Fig. 9A, the
source RNC cannot exchange data with the UE because its
RLC should be frozen after the transmission of the RLC
sequence numbers to the target RNC. Before the restart
of the RLC between target SRNC and UE (before point (b)
15   in Fig. 9A), data transfer cannot go on. All downstream
packets received by the target SRNC during this phase are
buffered until restart of the RLC between target SRNC and
UE.

       After point (c), in Fig. 9A, the connection is
20   established between UE and GGSN via Target RNC and SGSN2.

       Before resource release in source RNC (before T3-
TUNNEL expiry), target SRNC may receive downstream packet
from two paths. Packets remaining on the backbone are
sent on the "old path" (via SGSN1 and RNC1) and forwarded
25   by source RNC1 to target SRNC2 while packets received by
the GGSN on its Gi interface are sent on the new path
(via SGSN2) to target SRNC2.

       Fig. 11 shows data paths after the GGSN update
(after point (c) in Fig. 9A).

30   Fig. 12 shows data paths after the resource release
in source RNC (after the release response in Fig. 9A).

       Although the invention has been shown and described
with respect to a best mode embodiment thereof, it should
be understood by those skilled in the art that the

foregoing and various other changes, omissions and additions in the form and detail thereof may be made therein without departing from the spirit and scope of the invention.